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(54) DETERMINATION ON CASING AND FORMATION PROPERTIES USING ELECTROMAGNETIC MEASUREMENTS

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E21B 47/13	(2012.01)
G01V 3/30	(2006.01)

(52) **U.S. Cl.**
CPC ***E21B 47/092*** (2020.05); ***E21B 47/13*** (2020.05); ***G01V 3/30*** (2013.01)

(58) **Field of Classification Search**
CPC E21B 47/09; E21B 47/092; E21B 47/13; E21B 7/10; E21B 43/30; G01V 3/30
See application file for complete search history.

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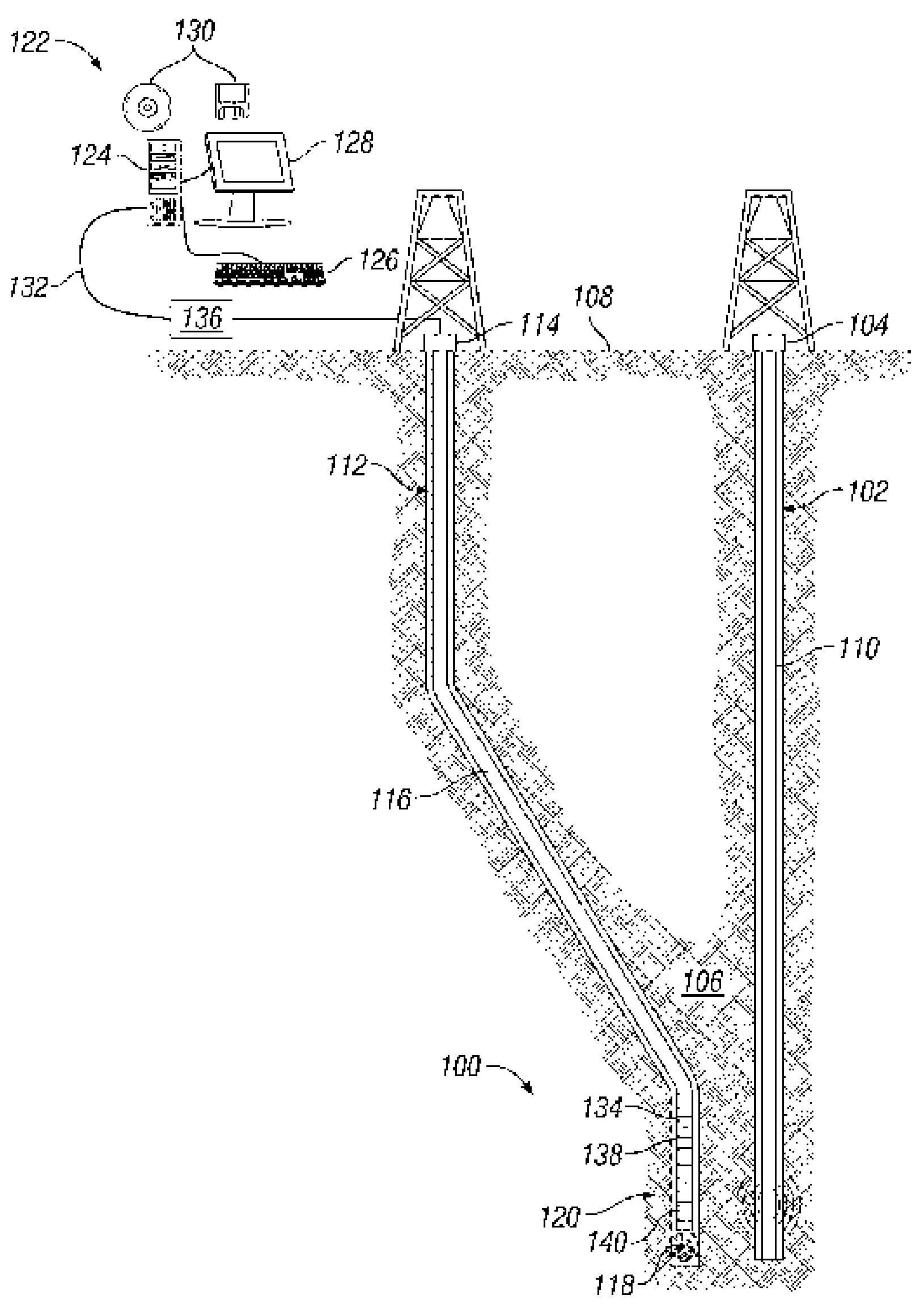
(57) ABSTRACT

A method and system for detecting a conductive member in a formation. The method may comprise disposing an electromagnetic induction tool into a wellbore, transmitting the electromagnetic field from the at least one electromagnetic source, energizing the conductive member in a second wellbore, wherein an eddy current is induced in the conductive member, transmitting a second electromagnetic field from the conductive member, wherein the second electromagnetic field is formed by the eddy current, sensing the second electromagnetic field with the receiver, recording an amplitude of the second electromagnetic field as data, and transmitting the data to an information handling system. A system for detecting a conductive member in a formation

(Continued)



may comprise an electromagnetic induction tool. The electromagnetic induction tool may comprise at least one electromagnetic source and at least one receiver. The system may further comprise an information handling system.

18 Claims, 7 Drawing Sheets

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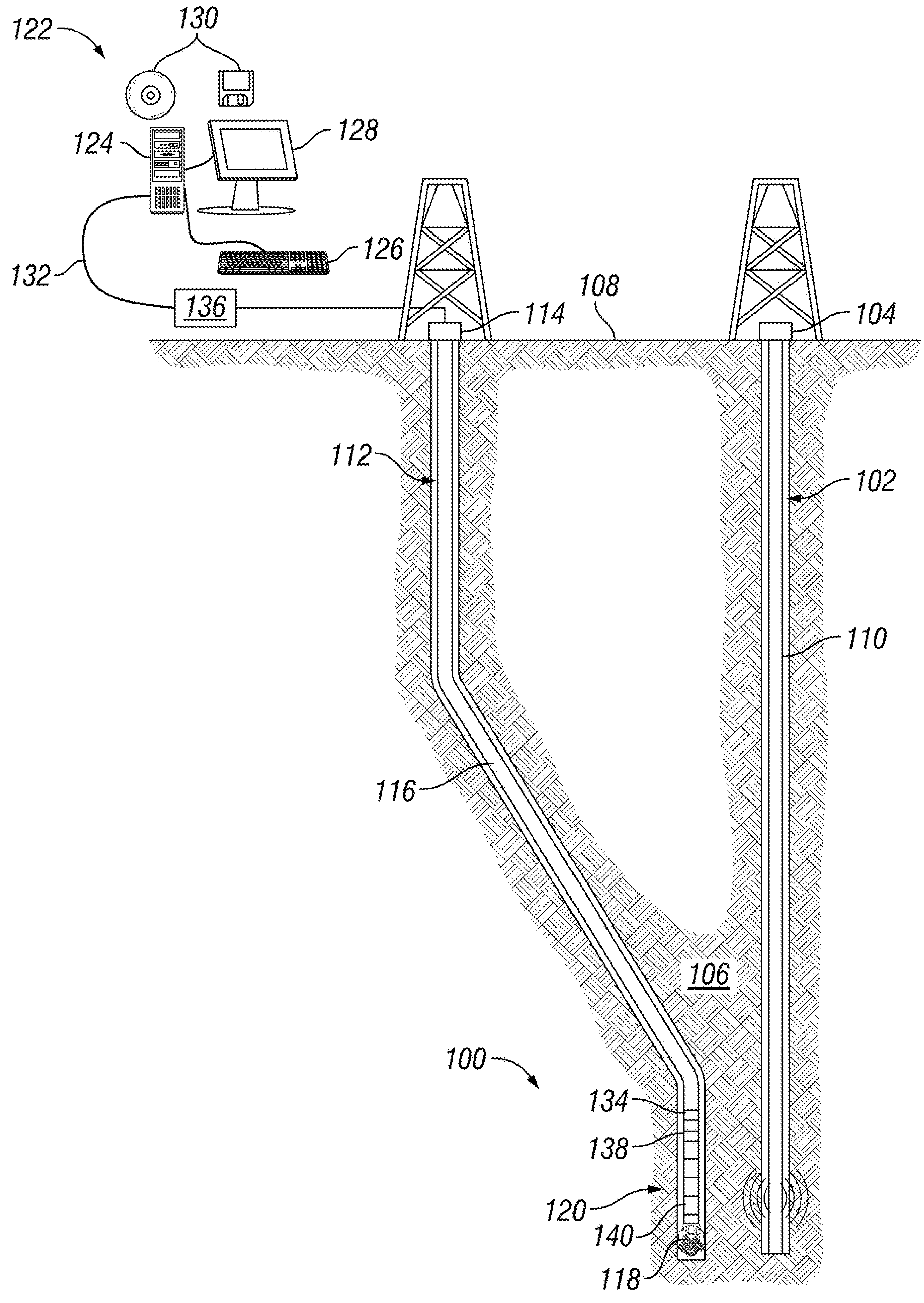


122
130
124
128
126
132
136
108
114
104
112
102
110
116
106
100
134
138
120
140
118

FIG. 1

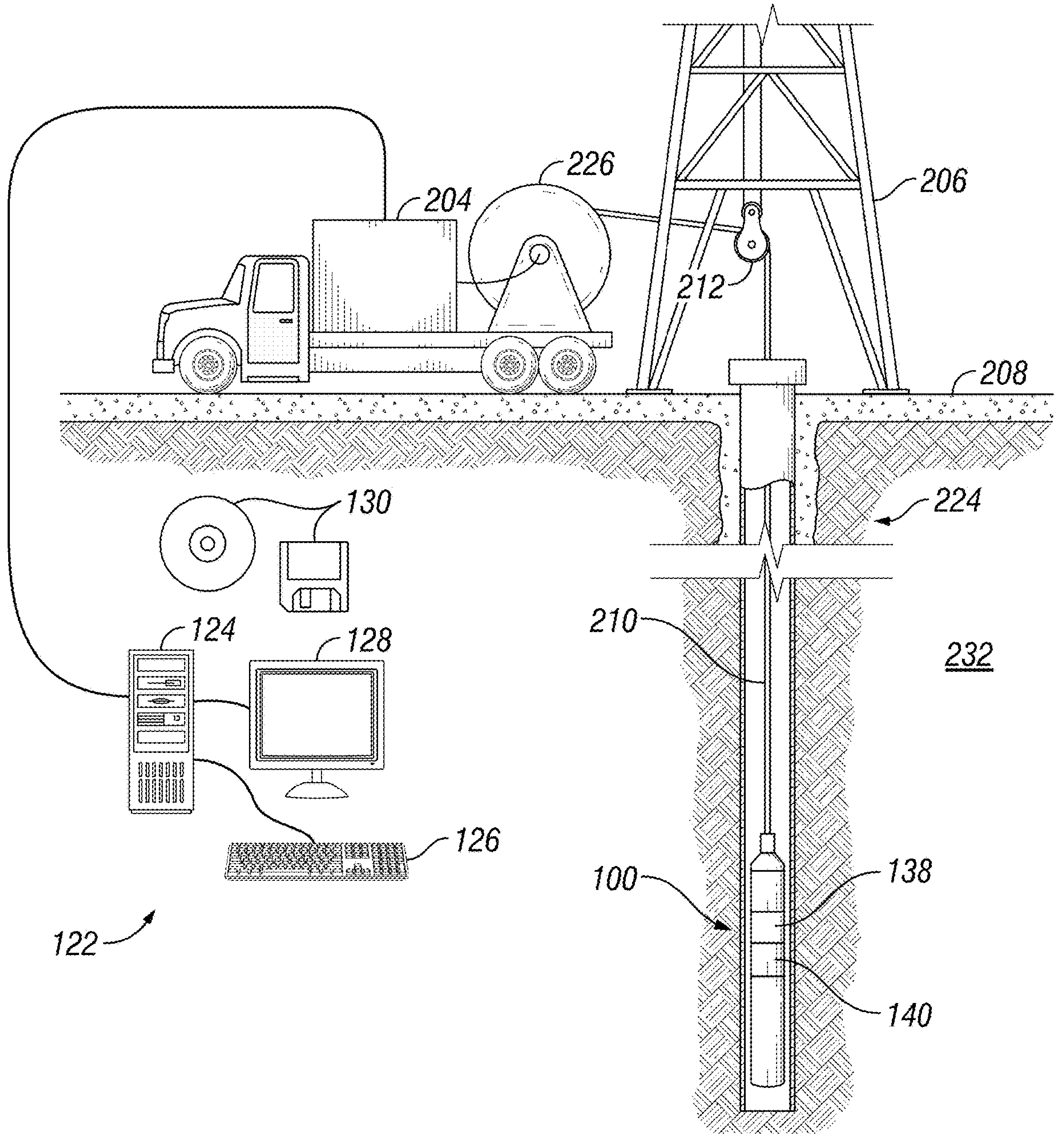
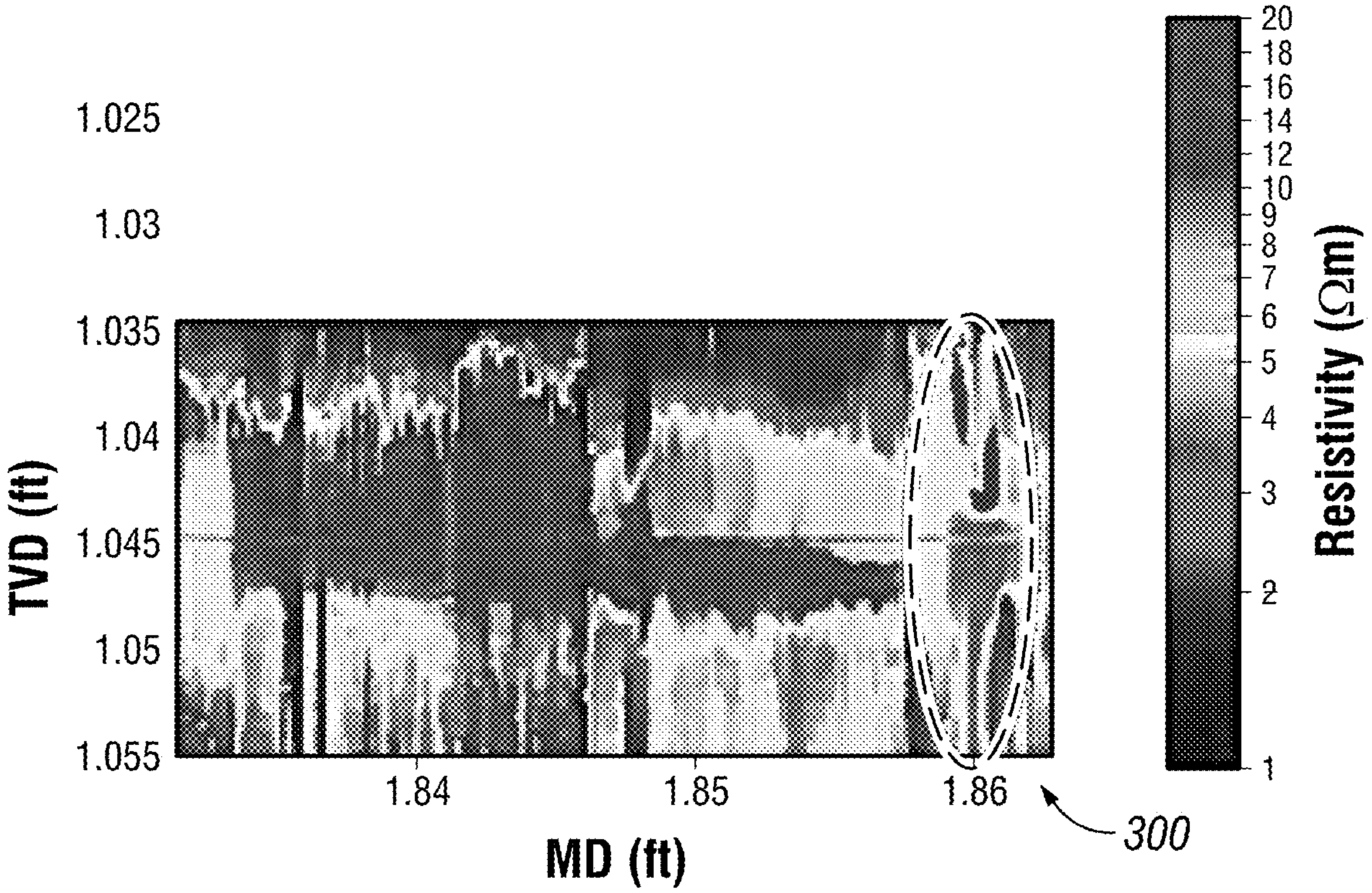


FIG. 2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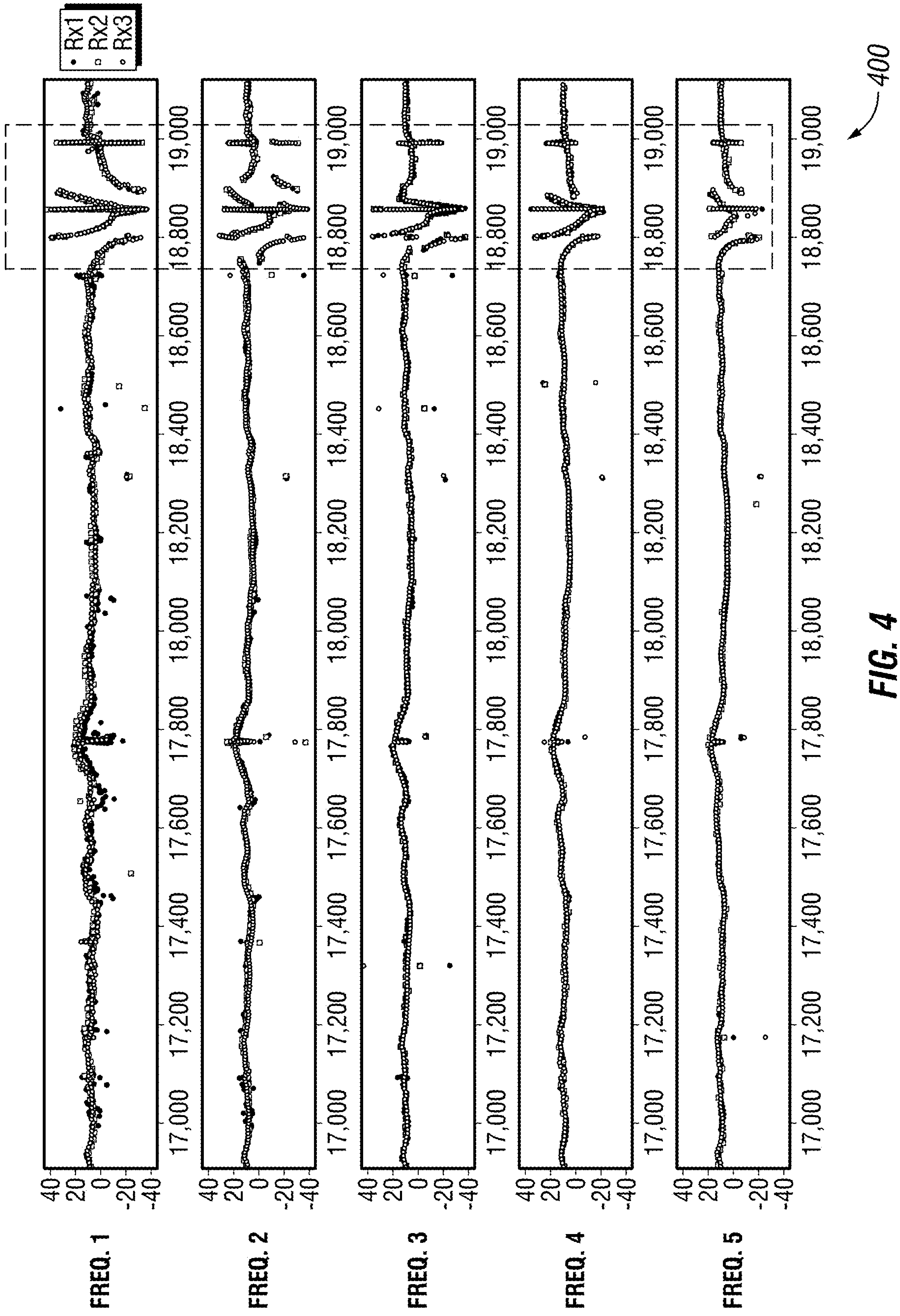
1.03
1.035
1.04
1.045
1.05
1.055
TVD (ft)
1.84
1.85
1.86
MD (ft)
300
20
18
16
14
12
10
9
8
7
6
5
4
3
2
1
Resistivity (Ωm)

FIG. 3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FREQ. 2
FREQ. 3
FREQ. 4
FREQ. 5
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0
-20
-40
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17,200
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17,600
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18,200
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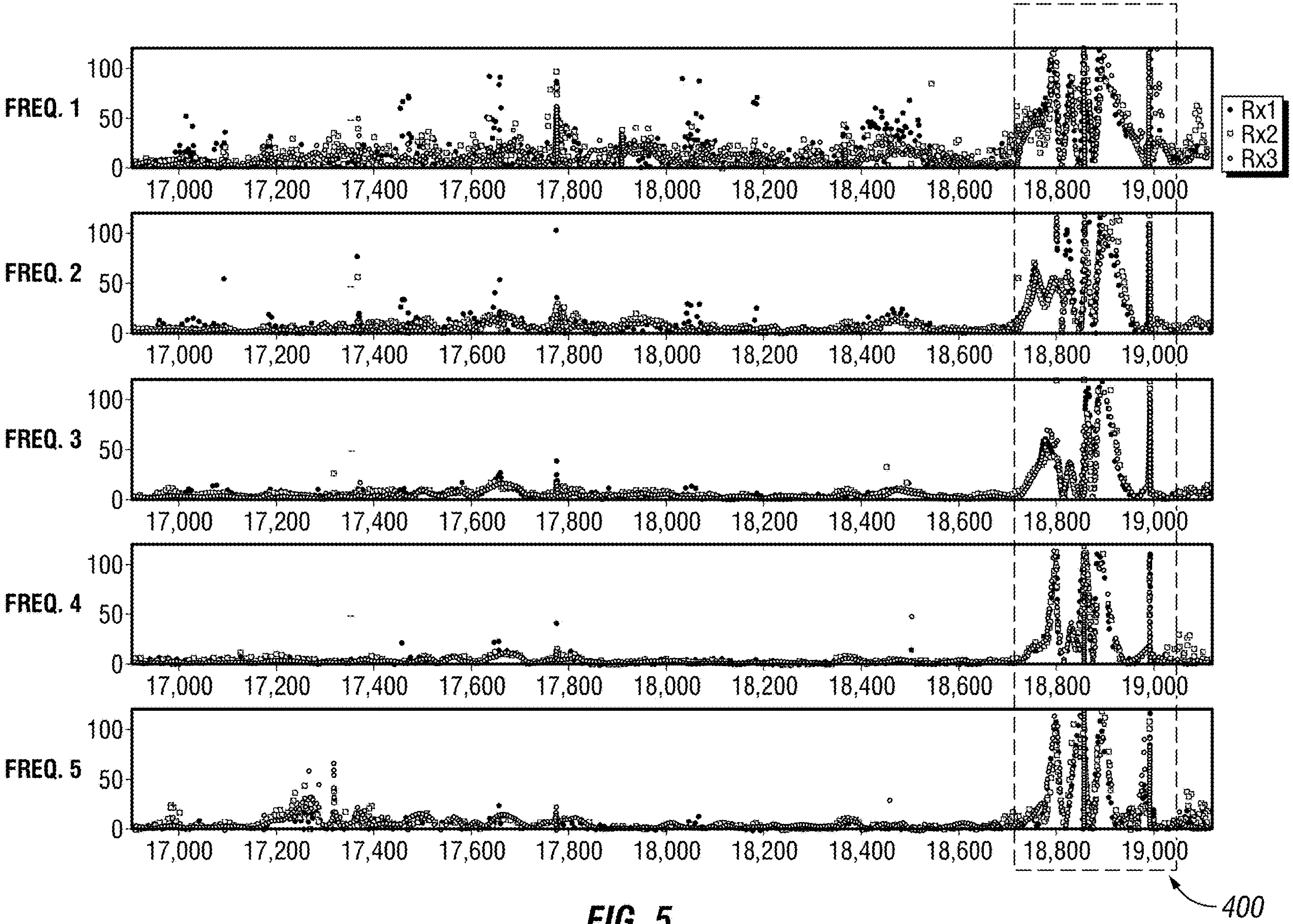
18,600
18,800
19,000
Rx1
Rx2
Rx3
400

FIG. 4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FREQ. 2
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FREQ. 5
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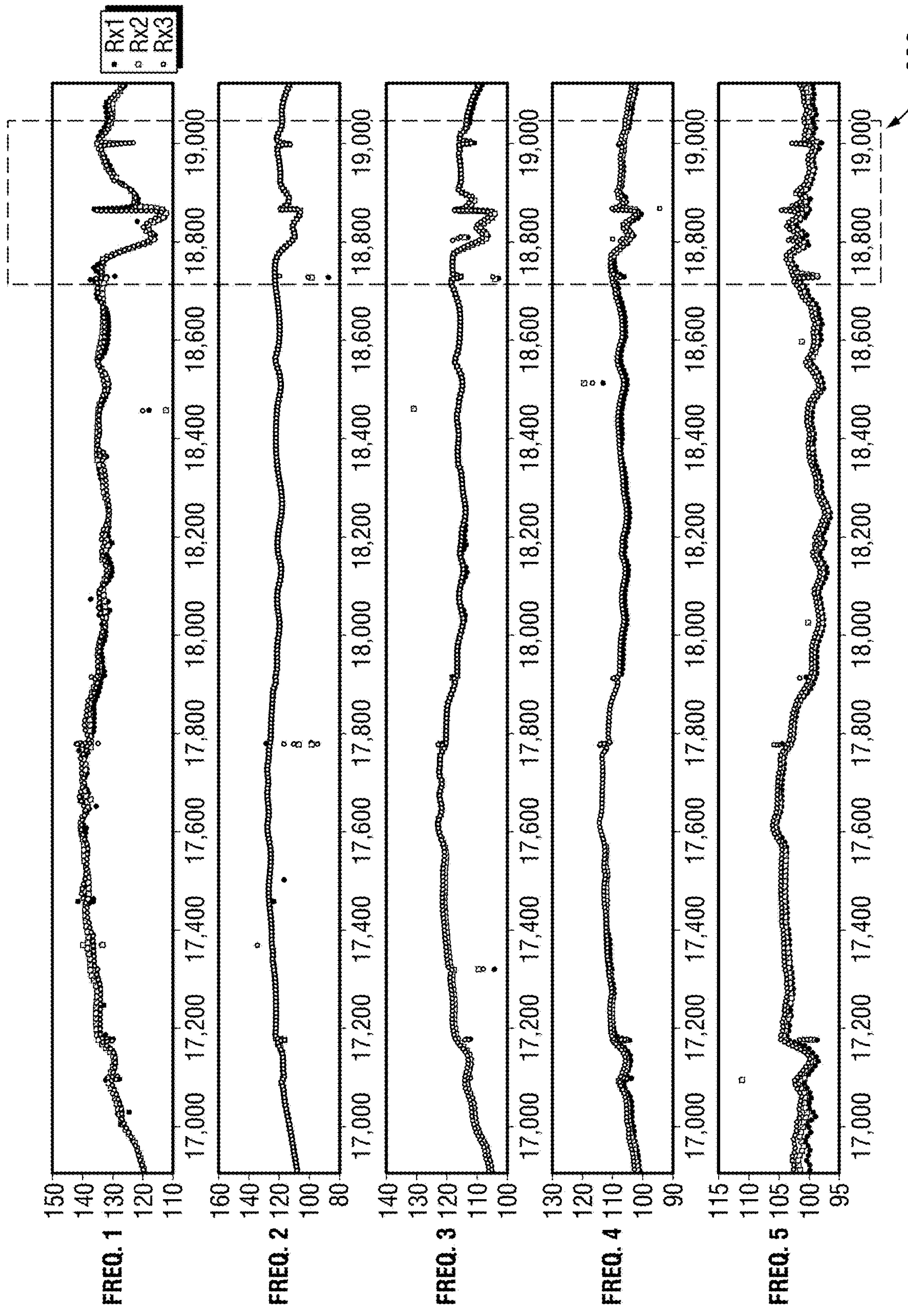
50
0
17,000
17,200
17,400
17,600
17,800
18,000
18,200
18,400
18,600
18,800
19,000
• Rx1
¤ Rx2
◦ Rx3
400

FIG. 5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140
130
120
110
FREQ. 2
160
140
120
100
80
FREQ. 3
140
130
120
110
100
FREQ. 4
130
120
110
100
90
FREQ. 5
115
110
105
100
95
17,000
17,200
17,400
17,600
17,800
18,000
18,200
18,400
18,600
18,800
19,000
Rx1
Rx2
Rx3
600

FIG. 6

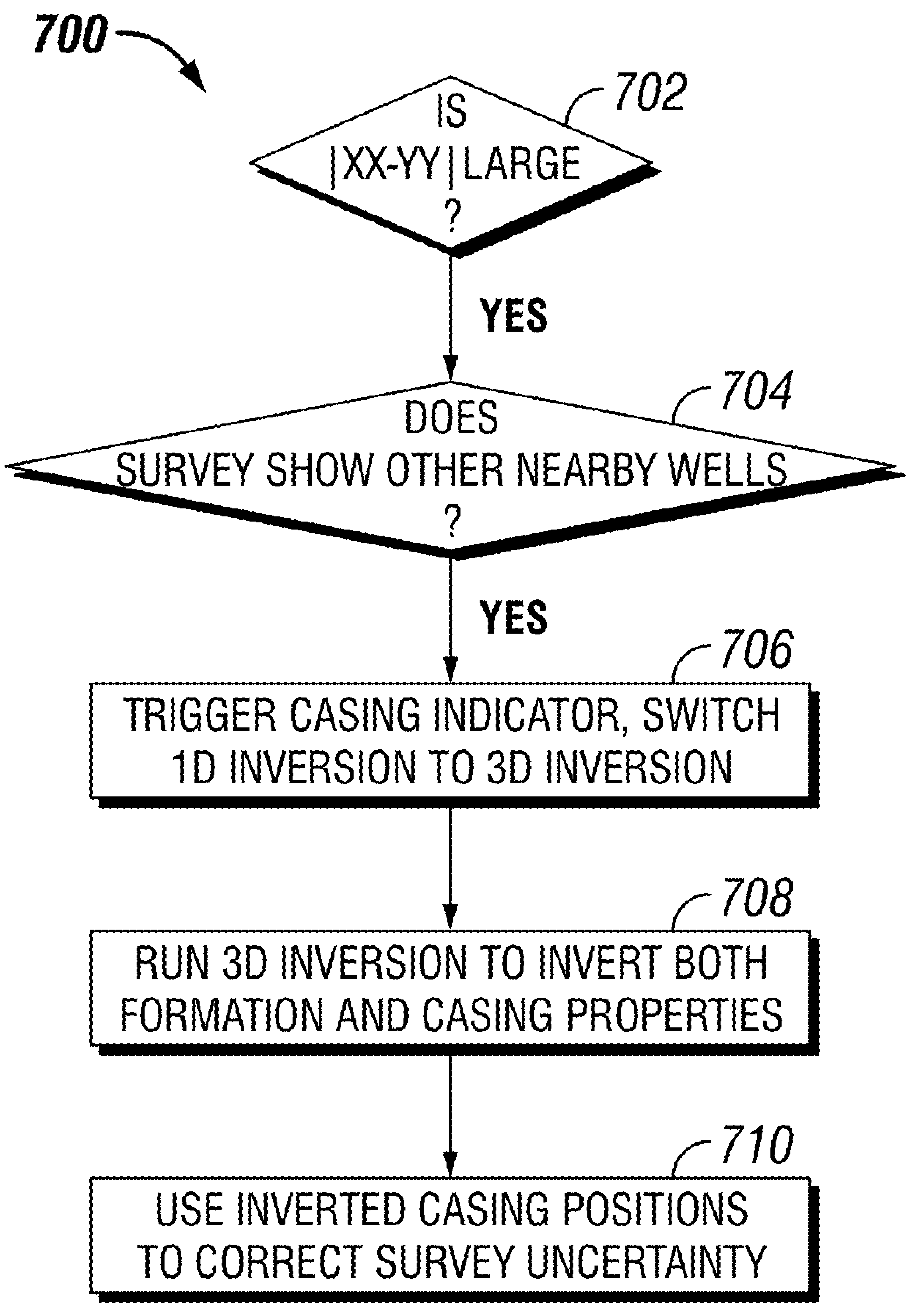
700
702
IS
|XX-YY| LARGE
?
YES
704
DOES
SURVEY SHOW OTHER NEARBY WELLS
?
YES
706
TRIGGER CASING INDICATOR, SWITCH 1D INVERSION TO 3D INVERSION
708
RUN 3D INVERSION TO INVERT BOTH FORMATION AND CASING PROPERTIES
710
USE INVERTED CASING POSITIONS TO CORRECT SURVEY UNCERTAINTY

FIG. 7

DETERMINATION ON CASING AND FORMATION PROPERTIES USING ELECTROMAGNETIC MEASUREMENTS

FIELD

The present disclosure relates to downhole electromagnetic induction tools and, more particularly, to apparatus and methods for detecting conductive members with the electromagnetic induction tool. As disclosed herein, the term "electromagnetic induction tool" denotes any electromagnetic tool which works at least in part based on induction principles. The term "electromagnetic induction tool" is not intended to limit the application to subterranean formation resistivity measurement and specifically includes ranging applications, where a distance and/or direction to a second wellbore may be calculated.

BACKGROUND

In well operations, it may be desirable to survey the formation for secondary wellbores using a downhole tool disposed in the wellbore. One type of downhole tool is an electromagnetic induction tool that may be used to make measurements of the electrical resistivity of earth formations penetrated by a wellbore or make measurements of distance and direction to a second well. Electromagnetic induction tools may be used in logging-while-drilling/measuring-while-drilling operations, electromagnetic ranging, wireline logging, and permanent monitoring systems, among others. Electromagnetic induction tools, or instruments, may typically comprise at least one electromagnetic source and at least one receiver. The electromagnetic source(s) and receiver(s) may be disposed on a tubular, such as a bottom hole assembly, mandrel, or casing joint. The electromagnetic induction tool may be implemented to determine the distance and direction to surrounding wells. Additionally, the electromagnetic induction tool may be disposed in a wellbore for the purpose of investigating electrical properties of subterranean formations and wells adjacent the wellbore. An electrical property of interest may be the electrical conductivity of particular portions of the formation. An alternating current having at least one frequency may be conducted through the electromagnetic source(s). The alternating current may induce eddy current to flow within the surrounding subterranean formations or in adjacent well casings. This eddy current in turn may induce voltages in the receiver(s).

BRIEF DESCRIPTION OF THE DRAWINGS

These drawings illustrate certain aspects of some examples of the present disclosure, and should not be used to limit or define the disclosure.

FIG. **1** is a schematic illustration of an electromagnetic induction tool in a wellbore;

FIG. **2** is another schematic illustration of an electromagnetic induction tool in a wellbore;

FIG. **3** is a graph of an inverted formation resistivity model;

FIG. **4** is a graph of an interrupted relative formation bed azimuth;

FIG. **5** is a graph of a 1D fitting error in signal processing;

FIG. **6** is a graph of amplitude compared in the XX and YY directions; and

FIG. **7** is a flow chart of conductive member detection using resistivity measurements.

DETAILED DESCRIPTION

This disclosure relates generally to electromagnetic induction tools and, more particularly, to determining in situ and/or during post processing distance and direction to at least one wellbore which may include a conductive tubular member (e.g., a casing). The electromagnetic induction tools may be used in a number of electromagnetic induction tools operations, such as measuring-while-drilling (MWD), logging-while-drilling (LWD), wireline logging, and permanent monitoring operations. Specifically, this disclosure relates to ultra-deep electromagnetic resistivity logging tools detecting other wellbores with conductive tubular members in complex formation. For example, tubulars, which may be conductive, may be disposed within the drill collar on a bottom hole assembly, a wireline tool mandrel, and/or permanently installed production casing. For brevity, the metallic tubular will be referred to as a tubular below. During drilling operations or logging operations it may be beneficial to know the location of other wellbores. When a tubular in a wellbore may be within the detection range of an ultra-deep electromagnetic tool, a sudden signal variation may be seen in measurement. The sudden signal variation may be viewed as an "interrupted formation model" during inversion procession, which may be undesirable because it may be geologically unrealistic. Current technology and operations may disregard and/or remove this data. However, this type of signal change may be used to detect a tubular in another wellbore. This may alert a drilling operator to another wellbore in an oil field. Furthermore, such signals may be used in a robust inversion to determine formation properties & bed-boundary positions, casing properties, and/or locations of tubulars in a wellbore.

Systems and methods of the present disclosure may be implemented, at least in part, with an information handling system. An information handling system may include any instrumentality or aggregate of instrumentalities operable to compute, estimate, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an information handling system may be a personal computer, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. The information handling system may include random access memory (RAM), one or more processing resources such as a central processing unit (CPU) or hardware or software control logic, ROM, and/or other types of nonvolatile memory. Additional components of the information handling system may include one or more disk drives, one or more network ports for communication with external devices as well as various input and output (I/O) devices, such as a keyboard, a mouse, and a video display. The information handling system may also include one or more buses operable to transmit communications between the various hardware components.

Alternatively, systems and methods of the present disclosure may be implemented, at least in part, with non-transitory computer-readable media. Non-transitory computer-readable media may include any instrumentality or aggregation of instrumentalities that may retain data and/or instructions for a period of time. Non-transitory computer-readable media may include, for example, storage media such as a direct access storage device (e.g., a hard disk drive or floppy disk drive), a sequential access storage device (e.g., a tape disk drive), compact disk, CD-ROM, DVD, RAM, ROM, electrically erasable programmable read-only memory (EEPROM), and/or flash memory; as well as communications media such wires, optical fibers, microwaves, radio waves, and other electromagnetic and/or optical carriers; and/or any combination of the foregoing.

FIG. **1** illustrates an electromagnetic induction tool **100**. Specifically, FIG. **1** shows an electromagnetic induction tool **100** for ranging. As illustrated, a first wellbore **102** may extend from a first wellhead **104** into a subterranean formation **106** from a surface **108**. Generally, first wellbore **102** may include horizontal, vertical, slanted, curved, and other types of wellbore geometries and orientations. First wellbore. **102** may be cased or uncased. A conductive member **110** may be disposed within first wellbore **102** and may comprise a metallic material that may be conductive and magnetic. By way of example, conductive member **110** may be a casing, liner, tubing, or other elongated steel tubular disposed in first wellbore **102**. Determining the position and direction of first wellbore **102** accurately and efficiently may be required in a variety of applications. For example, it may be desired to avoid collision with first wellbore **102** in drilling second wellbore **112** or it may be desired to drill the second wellbore **112** parallel to first wellbore **102**, for example, in SAGD applications. In examples, first wellbore **102** may not be accessible and/or information about the position and structure of first wellbore **102** may not be available. Electromagnetic sensor system **100** may be used for determining the location of first wellbore **102**, which may be further identified as a "target wellbore" with respect to second wellbore **112**.

With continued reference to FIG. **1**, second wellbore **112** may also extend from a second wellhead **114** that extends into subterranean formation **106** from surface **108**. Generally, second wellbore **112** may include horizontal, vertical, slanted, curved, and other types of wellbore geometries and orientations. Additionally, while first wellbore **102** and second wellbore **112** are illustrated as being land-based, it should be understood that the present techniques may also be applicable in offshore applications. Second wellbore **112** may be cased or uncased. In examples, a drill string **116** may begin at second wellhead **114** and traverse second wellbore **112**. A drill bit **118** may be attached to a distal end of drill string **116** and may be driven, for example, either by a downhole motor and/or via rotation of drill string **116** from surface **108**. Drill bit **118** may be a part of bottom hole assembly **120** at distal end of drill string **116**. While not illustrated, bottom hole assembly **120** may further comprise one or more of a mud motor, power module, steering module, telemetry subassembly, and/or other sensors and instrumentation as will be appreciated by those of ordinary skill in the art. As will be appreciated by those of ordinary skill in the art, bottom hole assembly **120** may be a measurement-while drilling (MWD) or logging-while-drilling (LWD) system.

While FIG. **1** illustrates use of electromagnetic induction tool **100** on drill string **116**, it should be understood that electromagnetic induction tool **100** may be alternatively used on any type of conveyance, further discussed below. In examples, electromagnetic induction tool 100 may be used in conjunction with information handling system for determining the distance and direction to first wellbore **102**. Systems and methods of the present disclosure may be implemented, at least in part, with information handling system **122**. Information handling system **122** may include any instrumentality or aggregate of instrumentalities operable to compute, estimate, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, information handling system **122** may be a personal computer **124**, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. Information handling system **122** may include random access memory (RAM), one or more processing resources such as a central processing unit (CPU) or hardware or software control logic, ROM, and/or other types of nonvolatile memory. Additional components of the information handling system may include one or more disk drives, one or more network ports for communication with external devices as well as various input and output (I/O) devices, such as a keyboard **126**, a mouse, and a video display **128**. Information handling system **122** may also include one or more buses operable to transmit communications between the various hardware components.

Alternatively, systems and methods of the present disclosure may be implemented, at least in part, with non-transitory computer-readable media. Non-transitory computer-readable media **130** may include any instrumentality or aggregation of instrumentalities that may retain data and/or instructions for a period of time. Non-transitory computer-readable media may include, for example, storage media such as a direct access storage device (e.g., a hard disk drive or floppy disk drive), a sequential access storage device (e.g., a tape disk drive), compact disk, CD-ROM, DVD, RAM, ROM, electrically erasable programmable read-only memory (EEPROM), and/or flash memory; as well as communications media such wires, optical fibers, microwaves, radio waves, and other electromagnetic and/or optical carriers; and/or any combination of the foregoing.

In examples, information handling system **122** may communicate with electromagnetic induction tool **100** through a communication line **132** disposed in (or on) drill string **116**. In examples, wireless communication may be used to transmit information back and forth between information handling system **122** and electromagnetic induction tool **100**. Information handling system **122** may transmit information to electromagnetic induction tool **100** and may receive as well as process information recorded by electromagnetic induction tool **100**. In addition, electromagnetic induction tool **100** may include a downhole information handling system **134**, which may also be disposed on bottom hole assembly **120**. Processing may be performed at surface with information handling system **122**, downhole with downhole information handling system **134**, or both at the surface and downhole. Downhole information handling system **134** may include, but is not limited to, a microprocessor or other suitable circuitry, for estimating, receiving and processing signals received by electromagnetic induction tool **100**. Downhole information handling system **134** may further include additional components, such as memory, input/output devices, interfaces, and the like. While not illustrated, bottom hole assembly **120** may include one or more additional components, such as analog-to-digital converter, filter and amplifier, among others, that may be used to process the measurements of electromagnetic induction tool **100** before they may be transmitted to surface **108**. Alternatively, raw measurements from electromagnetic induction tool **100** may be transmitted to surface **108**.

Any suitable technique may be used for transmitting signals from bottom hole assembly **120** to surface **108**, including, but not limited to, wired pipe telemetry, mud-pulse telemetry, acoustic telemetry, and electromagnetic telemetry. While not illustrated, bottom hole assembly **120** may include a telemetry subassembly that may transmit telemetry data to the surface. An electromagnetic source in the telemetry subassembly may be operable to generate pressure pulses in the drilling fluid that propagate along the fluid stream to surface **108**. At surface **108**, pressure transducers (not shown) may convert the pressure signal into electrical signals for a digitizer **136**. Digitizer **136** may supply a digital form of the telemetry signals to information handling system **122** via a communication link **132**, which may be a wired or wireless link. The telemetry data may be analyzed and processed by information handling system **122**.

In examples, electromagnetic induction tool **100** may comprise an electromagnetic source **138** and/or a receiver **140**. It should be noted that electromagnetic induction tool **100** may comprise a plurality of electromagnetic sources **138** and/or a plurality of receivers **140**. The plurality of electromagnetic sources **138** and the plurality of receivers **140** may be disposed along a longitudinal axis of the electromagnetic induction tool **100**. As disclosed, the concepts that are described herein are valid for any type of electromagnetic source **138** and receiver **140**. As an example, wire antenna, toroidal antenna and/or azimuthal button electrodes, transmitter coils, and/or receiver coils may also be used in the place of the electromagnetic source **138** and/or the receiver **140**. During operation electromagnetic source **138** may emit an electromagnetic field. The electromagnetic field may energize conductive member **110** of first wellbore **102**, which may produce an eddy current within conductive member **110**. The eddy current in conductive member **110** may in turn emit a secondary electromagnetic field, which may be sensed, measured, and/or recorded by receiver **140**. Information recorded by receiver **140** may be sent to downhole information handling system **134** and/or information handling system **122** disposed on surface **108**. The information may be further processed at downhole information handling system **134** and/or information handling system **122**.

Any suitable technique may be used for transmitting signals from electromagnetic induction tool **100** to surface **108**, including, but not limited to, wired pipe telemetry, mud-pulse telemetry, acoustic telemetry, and electromagnetic telemetry. While not illustrated, bottom hole assembly **120** may include a telemetry subassembly that may transmit telemetry data to the surface. An electromagnetic source in the telemetry subassembly may be operable to generate pressure pulses in the drilling fluid that propagate along the fluid stream to surface **108**. At surface **108**, pressure transducers (not shown) may convert the pressure signal into electrical signals for a digitizer **136**. Digitizer **136** may supply a digital form of the telemetry signals to information handling system **122** via a communication link **133**, which may be a wired or wireless link. The telemetry data may be analyzed and processed by information handling system **122**. For example, the telemetry data could be processed to determine location of target wellbore **102**. With the location of target wellbore **102**, a driller could control bottom hole body **120** through geos-steering while drilling second wellbore **112** to intentionally intersect target wellbore **102**, avoid target wellbore **102**, and/or drill second wellbore **112** in a path parallel to target wellbore **102**.

FIG. **2** illustrates another example of electromagnetic induction tool **100**. As illustrated, electromagnetic induction tool **100** may be attached a vehicle **204**. In examples, it should be noted that electromagnetic induction tool **100** may not be attached to a vehicle **204**. Electromagnetic induction tool **100** may be supported by rig **206** at surface **208**. Electromagnetic induction tool **100** may be tethered to vehicle **204** through conveyance **210**. Conveyance **210** may be disposed around one or more sheave wheels **212** to vehicle **204**. Conveyance **210** may include any suitable means for providing mechanical conveyance for electromagnetic induction tool **100**, including, but not limited to, wireline, slickline, coiled tubing, pipe, drill pipe, downhole tractor, or the like. In some embodiments, conveyance **210** may provide mechanical suspension, as well as electrical connectivity, for electromagnetic induction tool **100**. Conveyance **210** may comprise, in some instances, a plurality of electrical conductors extending from vehicle **204**. Conveyance **210** may comprise an inner core of seven electrical conductors covered by an insulating wrap. An inner and outer steel armor sheath may be wrapped in a helix in opposite directions around the conductors. The electrical conductors may be used for communicating power and telemetry between vehicle **204** and electromagnetic induction tool **100**. Information from electromagnetic induction tool **100** may be gathered and/or processed by information handling system **214**. For example, signals recorded by electromagnetic induction tool **100** may be stored on memory and then processed by electromagnetic induction tool **100**. The processing may be performed real-time during data acquisition or after recovery of electromagnetic induction tool **100**. Processing may alternatively occur downhole or may occur both downhole and at surface. In some embodiments, signals recorded by electromagnetic induction tool **100** may be conducted to information handling system **214** by way of conveyance **210**. Information handling system **214** may process the signals, and the information contained therein may be displayed for an operator to observe and stored for future processing and reference. Information handling system **214** may also contain an apparatus for supplying control signals and power to electromagnetic induction tool **100**.

Systems and methods of the present disclosure may be implemented, at least in part, with information handling system **122**. While shown at surface **208**, information handling system **122** may also be located at another location, such as remote from borehole **224**. Information handling system **122** may include any instrumentality or aggregate of instrumentalities operable to compute, estimate, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, or other purposes. For example, an information handling system **122** may be a personal computer **124**, a network storage device, or any other suitable device and may vary in size, shape, performance, functionality, and price. Information handling system **122** may include random access memory (RAM), one or more processing resources such as a central processing unit (CPU) or hardware or software control logic, ROM, and/or other types of nonvolatile memory. Additional components of the information handling system **122** may include one or more disk drives, one or more network ports for communication with external devices as well as various input and output (I/O) devices, such as a keyboard **126**, a mouse, and a video display **128**. Information handling system **122** may also include one or more buses operable to transmit communications between the various hardware components. Furthermore, video display **128** may provide an image to a user based on activities performed by personal computer **124**. For example, producing images of geological structures created from recorded signals. By way of example, a three-dimensional model of the subsurface structure.

Alternatively, systems and methods of the present disclosure may be implemented, at least in part, with non-transitory computer-readable media **130**. Non-transitory computer-readable media **130** may include any instrumentality or aggregation of instrumentalities that may retain data and/or instructions for a period of time. Non-transitory computer-readable media **130** may include, for example, storage media such as a direct access storage device (e.g., a hard disk drive or floppy disk drive), a sequential access storage device (e.g., a tape disk drive), compact disk, CD-ROM, DVD, RAM, ROM, electrically erasable programmable read-only memory (EEPROM), and/or flash memory; as well as communications media such wires, optical fibers, microwaves, radio waves, and other electromagnetic and/or optical carriers; and/or any combination of the foregoing.

In examples, rig **206** includes a load cell (not shown) which may determine the amount of pull on conveyance **210** at the surface of borehole **224**. Information handling system **214** may comprise a safety valve (not illustrated) which controls the hydraulic pressure that drives drum **226** on vehicle **204** which may reels up and/or release conveyance **210** which may move electromagnetic induction tool **100** up and/or down borehole **224**. The safety valve may be adjusted to a pressure such that drum **226** may only impart a small amount of tension to conveyance **210** over and above the tension necessary to retrieve conveyance **210** and/or electromagnetic induction tool **100** from borehole **224**. The safety valve is typically set a few hundred pounds above the amount of desired safe pull on conveyance **210** such that once that limit is exceeded, further pull on conveyance **210** may be prevented.

Electromagnetic induction tool **100** may comprise an electromagnetic source **138** and/or a receiver **140**. In examples, electromagnetic induction tool **100** may operate with additional equipment (not illustrated, i.e. shakers and equipment for producing shots) on surface **208** and/or disposed in a separate well measurement system (not illustrated) to record measurements and/or values. As discussed above, electromagnetic induction tool **100** during operation may determine the location of first wellbore **102** (e.g., referring to FIG. **1**) using electromagnetic field and/or eddy currents

During operations, for example, shallow or ultra-deep logging operations, of electromagnetic induction tool **100**, a real-time and/or post-processing solutions may be beneficial to operators. Electromagnetic induction tool **100** may be disposed in complex formations, where at least one cased-hole well, such as first wellbore **102** (Referring to FIG. **1**), may be disposed nearby. Referring to FIG. **1**, first wellbore **102** may be within the detection range of electromagnetic induction tool **100**, a sudden signal variation on the deep reading measurements may be recorded. This recorded measurement may cause interrupted formation model from inversion, which is undesirable since it is geological unrealistic. However, this type of signal change may be used to detect conductive member **110** of first wellbore **102**, not only for interpreting the inversion results, but also for raising a flag to the geosteering engineer to avoid first wellbore **102** during drilling. Furthermore, such signals may be used in a robust inversion to determine formation properties & bed-boundary positions as well as casing properties and locations.

A casing indicator method may be utilized to detect first wellbore **102** or any number of cased-hole wells surrounding second wellbore **112**. The casing indicator method may include three types of signals, which may trigger the casing indicator. The casing indicator method may include an interrupted relative formation bed azimuth from deep electromagnetic measurements, a large fitting error from the measurement signal processing using 1D formation assumption, a large signal difference between x- and y-component of the measurements, and survey profiles in a particular pad to indicate a casing nearby. The casing indicator method may be defined by three signals recorded, measured, and/or observed from multiple frequencies deep electromagnetic measurements and/or one method while drilling near existing wells. The casing indicator method may be utilized in an inversion to decouple formation properties (such as distance to bed boundaries positions, formation horizontal & vertical resistivity, formation dip, etc.) as well as the casing properties and positions of the existing wells nearby. In addition, the inverted casing positions may be further used to correct the survey uncertainty of the drilling well related to the existing wells nearby.

Once the casing indicator may be triggered, a unique inversion may be initialized to further invert both the properties of formation **106** (Referring to FIG. **1**) and conductive member **110** as well as the positions of formations **106** and conductive member **110**. The unique inversion includes the profile of conductive member **110** in the modeling calculations so that the inversion may be able to determine the final position and/or properties of conductive member **110**. The inverted formation properties may compensate for interruption of conductive member **110** in deep electromagnetic measurements. In addition, the inverted conductive member positions related to the drilling well may be packaged at a formation data product and sold or presented to a client, which may include the survey corrections based on the inverted conductive member positions.

The distance-to-bed-boundary inversions may be improved by including signals of conductive member **110** in the inversion. Correction on survey uncertainty is also available owing to independent deep electromagnetic measurements at each logging point. The survey data have accumulated errors, whereas the deep electromagnetic measurements do not have such issue and are truly independent of each measurement position related to the cased-hole wells nearby. Additionally, the casing indicator method may provide additional service base on existing tools hardware and improve the log interpretation with higher confidence for evaluations of formations **106** (Referring to FIG. **1**), including formation resistivity determination (Rh and Av), formation dip inversion, formation distance-to-bed-boundary inversion. Additional answer product of survey uncertainty correction may be provided from the inversion.

Acquired during horizontal well drilling through electromagnetic induction tool **100**, deep electromagnetic measurements may fed into information handling system **122** and utilized in an inversion calculation. The inversion calculation may assumes a ten layered model, in which the results may be a lowly varying ten layer formation **106** (Referring to FIG. **1**) in which boundaries of formation **106** may be continuous. In examples, as illustrated in FIG. **3**, the measured inverted boundary has a sudden variation as in the circled area **300**, which raises the concern about the inversion accuracy. Analysis shows that this interrupted formation boundary is due to signal changing caused by casing of nearby wells, such as first wellbore **102** (Referring to FIG. **1**).

Besides an inversion resistivity curtain plot, three different signals may be used to monitor the effect of conductive member **110**. One is the interrupted relative formation bed azimuth as shown in FIG. **4**. In a 1D (one dimensions) view of formation **106**, as seen in FIG. **3**, the azimuth may be constant. Any sudden change in the bed azimuth indicates a 3D effect which may be related to conductive member **110** and this type of change may be observed in signals of multiple frequencies. The second is the large 1D fitting error in the signal processing which may indicate 3D effect as shown in FIG. **5**. The identified area **400** in both FIGS. **4** and **5** shows where the deep electromagnetic measurements may affected by the nearby conductive member **112**.

Additionally, a nearby conductive member **110** (Referring to FIG. **1**) may be identified by a large difference between XX and YY component, as illustrated in FIG. **6**. In examples, the induced eddy current in conductive member **110**, as discussed above, may form a second electromagnetic field, which may be sensed, measured, and/or recorded by receiver **130**. Receiver **130** may measure amplitude of the second electromagnetic field. Components of the second electromagnetic field may be XX and/or YY. It should be noted that the XX measurement may be a measurement along the X-axis and the YY measurement may be a measurement along the Y-axis, relative to receiver **130**. The XX or YY measurement may be close to the parallel position to conductive member **110**, which may induce a strong signal, while the other signal is perpendicular to conductive member **110**, which may induce a weak signal. Using the equation, |XX-YY|, one measurement, the perpendicular measurement, may be about zero. In such a case, the absolute value from the equation may be the parallel measurement. FIG. **6** shows the amplitude of |XX-YY| and the identified area **600** may indicate where electromagnetic induction tool **100** may have measure conductive member **110** nearby. As illustrated, the amplitude is larger than other recorded amplitude. Specifically, large means at least a ten percent increase (positive or negative) from previous measurements.

FIG. **7** illustrates conductive member detection method **700**. In step **702**, the |XX-YY| amplitude obtained to indicate the presence of conductive member **110** (Referring to FIG. **1**). If the amplitude is large, then in step **704**, the measured signal may be combined with the survey data among multiple wells as the casing indicator, discussed above, which may trigger the casing indicator, step **706**. Once the casing indicator is triggered, the 1D deep resistivity inversion may be switched to a 3D inversion. The 3D inversion may include a possible position of conductive member **110** as an initial model before the inversion. Both formation resistivity and resistivity of conductive member **110** may be inverted in the inversion.

In step **706**, a thin-wire approximation may be used for resistivity calculation of conductive member **110** (Referring to FIG. **1**) to speed up 3D modeling computations. In step **708**, the 3D inversion may be utilized to invert both resistivity of formation **106** and/or properties of conductive member **110**. In step **710**, the inverted position of conductive member **110** may be used to correct the survey uncertainty of the drilling well related to the existing wells, such as first wellbore **102**, nearby. The method is not only applicable for deep electromagnetic tools but also for shallow tools.

It should be noted that the methods discussed above may be utilized to further determine the properties of the casing and/or conductive members disposed in second wellbore **112** in which electromagnetic sensor system **100** may be disposed.

Statement 1. A method for detecting a conductive member in a formation may comprise disposing an electromagnetic induction tool into a wellbore. The electromagnetic induction tool may comprise at least one electromagnetic source, wherein the at least one electromagnetic source is configured to emit an electromagnetic field and at least one receiver. The method may further comprise transmitting the electromagnetic field from the at least one electromagnetic source, energizing the conductive member in a second wellbore, wherein an eddy current is induced in the conductive member, transmitting a second electromagnetic field from the conductive member, wherein the second electromagnetic field is formed by the eddy current, sensing the second electromagnetic field with the receiver, recording an amplitude of the second electromagnetic field as data, and transmitting the data to an information handling system.

Statement 2. The method of statement 1, wherein the amplitude comprise an XX signal and an YY signal.

Statement 3. The method of statements 1 or 2, wherein the amplitude is processed using |XX-YY| to determine the presence of the conductive member.

Statement 4. The method of statements 1 to 3, further comprising comparing the amplitude to a survey data, wherein the survey data includes data from at least one other wellbore.

Statement 5. The method of statements 1 to 4, further comprising triggering a casing indicator, wherein the amplitude and the survey data indicate at least one other wellbore is in the oil field.

Statement 6. The method of statements 1 to 5, further comprising switching from a 1D inversion to a 3D inversion and running the 3D inversion to invert a property of a formation or a property of the conductive member.

Statement 7. The method of statements 1 to 6, further comprising updating the survey data with the property of the formation or the property of the conductive member.

Statement 8. The method of statements 1 to 7, wherein the electromagnetic induction tool is disposed on a conveyance.

Statement 9. The method of statements 1 to 8, wherein the electromagnetic induction tool is disposed on a drill string.

Statement 10. The method of statements 1 to 9, further comprising changing directions of the drill string based at least in part on the amplitude.

Statement 11. A system for detecting a conductive member in a formation may comprise an electromagnetic induction tool. The electromagnetic induction tool may comprise at least one electromagnetic source, wherein the at least one electromagnetic source is configured to emit an electromagnetic field, and at least one receiver, wherein the at least one receiver is configured to measure an amplitude of a second electromagnetic field. The system may further comprise an information handling system configured to process the amplitude of the second electromagnetic field using |XX-YY| to find an absolute value of the amplitude, and comparing the absolute value to at least one other measurement recorded by the at least one receiver.

Statement 12. The system of statement 11, wherein the information handling system is further configured to compare a survey data to the absolute value of the amplitude.

Statement 13. The system of statements 11 or 12, wherein the information handling system is further configured to run a 3D inversion to invert a property of a formation or a property of the conductive member.

Statement 14. The system of statements 11 to 13, wherein the information handling system is further configured to update the survey data with the property of the formation or the property of the conductive member.

Statement 15. The system of statements 11 to 14, wherein the electromagnetic induction tool is disposed on a conveyance.

Statement 16. The system of statements 11 to 15, wherein the electromagnetic induction tool is disposed on a drill string.

Statement 17. A method for detecting a conductive member in a formation may comprise measuring an XX and YY of an amplitude from an electromagnetic field with a receiver, using |XX-YY| to find an absolute value of the amplitude, comparing the absolute value to a survey data, triggering a casing indicator, wherein the amplitude and the survey data indicate at least one other wellbore is in the oil field, and switching from a 1D inversion to a 3D inversion and running the 3D inversion to invert a property of a formation or a property of the conductive member.

Statement 18. The method of statement 17, further comprising updating the survey data with the property of the formation or the property of the conductive member

Statement 19. The method of statements 17 or 18, wherein the electromagnetic induction tool is disposed on a conveyance.

Statement 20. The method of statement 17 to 19, wherein the electromagnetic induction tool is disposed on a drill string.

The preceding description provides various examples of the systems and methods of use disclosed herein which may contain different method steps and alternative combinations of components. It should be understood that, although individual examples may be discussed herein, the present disclosure covers all combinations of the disclosed examples, including, without limitation, the different component combinations, method step combinations, and properties of the system. It should be understood that the compositions and methods are described in terms of "comprising," "containing," or "including" various components or steps, the compositions and methods can also "consist essentially of" or "consist of" the various components and steps. Moreover, the indefinite articles "a" or "an," as used in the claims, are defined herein to mean one or more than one of the element that it introduces.

For the sake of brevity, only certain ranges are explicitly disclosed herein. However, ranges from any lower limit may be combined with any upper limit to recite a range not explicitly recited, as well as, ranges from any lower limit may be combined with any other lower limit to recite a range not explicitly recited, in the same way, ranges from any upper limit may be combined with any other upper limit to recite a range not explicitly recited. Additionally, whenever a numerical range with a lower limit and an upper limit is disclosed, any number and any included range falling within the range are specifically disclosed. In particular, every range of values (of the form, "from about a to about b," or, equivalently, "from approximately a to b," or, equivalently, "from approximately a-b") disclosed herein is to be understood to set forth every number and range encompassed within the broader range of values even if not explicitly recited. Thus, every point or individual value may serve as its own lower or upper limit combined with any other point or individual value or any other lower or upper limit, to recite a range not explicitly recited.

Therefore, the present examples are well adapted to attain the ends and advantages mentioned as well as those that are inherent therein. The particular examples disclosed above are illustrative only, and may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Although individual examples are discussed, the disclosure covers all combinations of all of the examples. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. Also, the terms in the claims have their plain, ordinary meaning unless otherwise explicitly and clearly defined by the patentee. It is therefore evident that the particular illustrative examples disclosed above may be altered or modified and all such variations are considered within the scope and spirit of those examples. If there is any conflict in the usages of a word or term in this specification and one or more patent(s) or other documents that may be incorporated herein by reference, the definitions that are consistent with this specification should be adopted.

What is claimed is:

1. A method for detecting a conductive member in a formation comprising:

disposing an electromagnetic induction tool into a wellbore, wherein the electromagnetic induction tool comprises:

at least one electromagnetic source, wherein the at least one electromagnetic source is configured to emit an electromagnetic field; and

at least one receiver;

transmitting the electromagnetic field from the at least one electromagnetic source;

energizing the conductive member in a second wellbore, wherein an eddy current is induced in the conductive member;

transmitting a second electromagnetic field from the conductive member, wherein the second electromagnetic field is formed by the eddy current;

sensing the second electromagnetic field with the receiver;

recording an amplitude of the second electromagnetic field as data, wherein the amplitude comprises an XX signal and an YY signal;

transmitting the data to an information handling system; and

processing the amplitude using |XX-YY| to determine the presence of the conductive member.

2. The method of claim **1**, further comprising comparing the amplitude to a survey data, wherein the survey data includes data from at least one other wellbore.

3. The method of claim **2**, further comprising triggering a casing indicator, wherein the amplitude and the survey data indicate at least one other wellbore is in the oil field.

4. The method of claim **3**, further comprising switching from a 1D inversion to a 3D inversion and running the 3D inversion to invert a property of a formation or a property of the conductive member.

5. The method of claim **4**, further comprising updating the survey data with the property of the formation or the property of the conductive member.

6. The method of claim **1**, wherein the electromagnetic induction tool is disposed on a conveyance.

7. The method of claim **1**, wherein the electromagnetic induction tool is disposed on a drill string.

8. The method of claim **7**, further comprising changing directions of the drill string based at least in part on the amplitude.

9. A system for detecting a conductive member in a formation comprising:

an electromagnetic induction tool, wherein the electromagnetic induction tool comprises:

at least one electromagnetic source, wherein the at least one electromagnetic source is configured to emit an electromagnetic field; and at least one receiver, wherein the at least one receiver is configured to measure an amplitude of a second electromagnetic field; and

an information handling system configured to:

process the amplitude of the second electromagnetic field using |XX-YY| to find an absolute value of the amplitude, and

comparing the absolute value to at least one other measurement recorded by the at least one receiver.

10. The system of claim **9**, wherein the information handling system is further configured to compare a survey data to the absolute value of the amplitude.

11. The system of claim **10**, wherein the information handling system is further configured to run a 3D inversion to invert a property of a formation or a property of the conductive member.

12. The system of claim **11**, wherein the information handling system is further configured to update the survey data with the property of the formation or the property of the conductive member.

13. The system of claim **9**, wherein the electromagnetic induction tool is disposed on a conveyance.

14. The system of claim **9**, wherein the electromagnetic induction tool is disposed on a drill string.

15. A method for detecting a conductive member in a formation comprising:

measuring an XX and YY of an amplitude from an electromagnetic field with a receiver disposed on an electromagnetic induction tool;

using |XX-YY| to find an absolute value of the amplitude;

comparing the absolute value to a survey data;

triggering a casing indicator, wherein the amplitude and the survey data indicate at least one other wellbore is in the oil field; and

switching from a 1D inversion to a 3D inversion and running the 3D inversion to invert a property of a formation or a property of the conductive member.

16. The method of claim **15**, further comprising updating the survey data with the property of the formation or the property of the conductive member.

17. The method of claim **15**, wherein the electromagnetic induction tool is disposed on a conveyance.

18. The method of claim **15**, wherein the electromagnetic induction tool is disposed on a drill string.

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